

## Chronology, deforestation, and "collapse:" Evidence vs. faith in Rapa Nui prehistory

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In recent publications (Hunt and Lipo 2006; Hunt 2006, 2007) we have presented a detailed and comprehensive analysis of new and existing archaeological information as it relates to the date of Rapa Nui's colonization, the island's ecological transformation and the assumed relationship to "collapse." After reviewing published dates and our results at 'Anakena, we came to the conclusion that although it is *conceptually* possible that humans arrived on the island many hundreds of years prior to AD 1200, there is currently no empirical support for believing this was so. Until unequivocal evidence emerges for earlier colonization, our understanding of the island's prehistory must be founded on a shorter chronology of about 800 years.

Our re-examination of the evidence for Rapa Nui has provoked quite negative reactions (Flenley and Bahn 2007a; 2007b). In this paper we address some of the issues raised in the responses to our work. We argue the critical problem has come from ignoring the *empirical sufficiency* of archaeological and palaeo-environmental conclusions. Unfortunately, the popular narrative, one of more than a millennium of population growth resulting in environmental catastrophe and demographic collapse, so often repeated for Rapa Nui, has enjoyed precedent over the actual evidence, or lack of it. Contrary to the strictures of science, continued *faith* in a particular story for Rapa Nui has closed the minds of some scholars to considering new evidence, or re-evaluating the old.

In a remarkable set of discoveries, John Flenley and his colleagues (e.g., Dransfield et al. 1984; Flenley and King 1984; Flenley et al. 1991) found that the pollen evidence from a series of lake cores indicated that Rapa Nui once supported a forest dominated by a giant palm tree (an extinct *Jubaea* sp. [Grau 2004] or *Paschalococos disperta* [Dransfield et al. 1984]). Their work confirmed what others had suspected about a native forest that had disappeared (e.g., Skottsberg 1956; Mulloy and Figueroa 1978:22). Flenley's pioneering palynological work showed that Rapa Nui had undergone a dramatic ecological transformation with deforestation and associated extinctions (Steadman et al. 1994; Steadman 2006).

It seemed obvious to researchers that Rapa Nui was a clear case of human recklessness, over-population, over-exploitation, and cultural collapse. Given contemporary

concerns about our own environmental future, Rapa Nui offered the quintessential case of "ecocide," as Jared Diamond (2005) dubbed it. The case for "ecocide" seemed consistent with some accounts from early European visitors, some of the oral traditions, Heyerdahl's views of pervasive warfare and cultural replacement, and the emerging palaeo-ecological evidence. Rapa Nui provided a compelling story and environmental message that held relevance in today's urgent global crisis (e.g., Kirch 1997, 2004). While we are certainly concerned about contemporary environmental problems, we ask, have the causes and consequences of Rapa Nui *deforestation* been misconstrued in accounts for "ecocide" and cultural collapse?

Recent field research has changed some of the details of Rapa Nui's prehistory (e.g., Hunt and Lipo 2006; Hunt 2006, 2007), and received widespread press (e.g., Gibbons 2006; Lovgren 2006; Young 2006). A series of eight new radiocarbon dates from excavations of stratified deposits at 'Anakena show occupation began by approximately AD 1200.

The shorter chronology for Rapa Nui follows the pattern that has emerged for chronologies throughout eastern Polynesia (e.g., Anderson 1991; Anderson and Sinoto 2002; Athens et al. 2002; Burney and Burney 2003; Higham and Hogg 1997; Kennett et al. 2006; Spriggs and Anderson 1993). Moreover, recent research on deforestation and avian extinctions in the Hawaiian Islands (Athens et al. 2002) has demonstrated that the Pacific rat, introduced to islands by Polynesian colonists, irrupted into millions, expanding over the landscape many times faster than people (see Fenchel 1974). This invasive species consumed seeds of native plants, effectively depressing or halting the regeneration of many forest taxa. The ecological impacts of rats are well documented (e.g., Campbell 1978; Campbell and Atkinson 1999, 2002; Towns et al. 2006). Before the effects of fire, felling, or other direct human actions, Athens et al. (2002) have shown that the introduced rat destroyed the *Pritchardia* palm forests of the 'Ewa Plain of O'ahu Island. Other palaeo-environmental field studies (e.g., Athens 1997; Denham et al. 1999) point to comparable impacts on native forests from rats. The implication is that rats played a significant role in the collapse of forest over much of the lowland areas of the Hawaiian Islands as well as elsewhere

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in the Pacific. If rats alone devastated huge tracts of Hawaiian forest, what relative impact might they have had on Rapa Nui, an island a fraction of the size, with a depauperate biota, and no natural predators (Figure 1)? This question is partially answered by considering the relatively simple, but almost ideal “rat-fodder” native vegetation of remote Rapa Nui: the ancient palm and its abundant nuts (Hunt 2007).



Figure 1. Scaled overlay of Rapa Nui and O'ahu islands; compare the relatively large area of *Pritchardia* deforestation of the 'Ewa Plain (and lowland O'ahu generally) with the small total size of Rapa Nui (171 km<sup>2</sup>).

## REACTIONS

In a letter to the editor of *American Scientist* and the paper recently published in this journal, Flenley and Bahn (2007a, 2007b) question the legitimacy of new evidence and its implications for Rapa Nui prehistory (Hunt 2006, 2007). They appear to simply defend views previously published (e.g., Flenley and Bahn 2002; see also Diamond 2005). Flenley and Bahn (2007a, 2007b) assert that archaeological and botanical data unambiguously point to human over-exploitation of resources on Rapa Nui, and that this interpretation is consistent with an account that centers on self-induced collapse or Diamond's “ecocide” prior to European contact. They challenge our primary evidence and careful examination of the archaeological and palaeo-environmental records, and instead lobby for the accuracy of their story for the island. Here we argue that it is critical that we evaluate the *evidence*, not just cling to long-held beliefs based on *faith* in the absence of evidence, problematic oral histories, and appeals to authority concerning the island's ecological and cultural past.

## A LONGER OR SHORTER CHRONOLOGY?

### New Evidence

Renewed excavations of the stratified deposits on the north (seaward) side of Ahu Nau Nau at 'Anakena Beach have yielded significant evidence for the chronology of the island's colonization (Hunt and Lipo 2006; Hunt 2007). Long held to be the site of early settlement (e.g., Routledge 1919:241-242; Heyerdahl 1961a:34-36; Steadman et al. 1994; Skjølsvold 1994a), 'Anakena is the site of a stratified dune with cultural deposits extending down to a natural clay substrate. This clay substrate contains an organically enriched palaeosol with abundant cultural materials (e.g., obsidian artifacts, rat bones, charcoal) embedded in its uppermost 5-10 cm. Below this ancient horizon is a natural undisturbed clay deposit riddled with the root molds of the extinct palm. The root molds provide evidence that natural sedimentation (weathered volcanic ash) occurred at some ancient (geologic) time, and had been undisturbed for at least several centuries before AD 1200. Our three seasons of excavations and deep coring have confirmed that this basal clay substrate extends several meters below and is entirely devoid of cultural materials. Thus, the palaeosol at the interface of the clay substrate and the sand layers above formed a stable ground surface at the time of first colonization of the island. This stratigraphic interface provides a sound context to date the arrival of Polynesian colonists on Rapa Nui. Multiple radiocarbon dates from this context and the sand dune above show a consistently ordered chronology beginning around AD 1200. Considering the number of radiocarbon dates, consistency of chronological results ordered stratigraphically, and analysis of the geomorphic and sedimentary context, these results from the 'Anakena Dune are among the most complete published for Rapa Nui.

### Veracity of Earliest Cultural Deposits

Flenley and Bahn (2007a, 2007b) claim that our evidence for chronology is weak. They simply assert that no natural (i.e., pre-cultural) layers are beneath the cultural ones that we excavated. They also assert that earlier cultural layers *could have* existed but are now missing. Flenley and Bahn (2007a, 2007b) suggest that older layers of sand might have blown or washed away before those we excavated were deposited. Sand dunes are dynamic environments; they develop, erode, and change rapidly. Yet the undisturbed state of the original *in situ* clay substrate (i.e., below the sand layers) is indicated by artifacts, charcoal, rat bones, etc., embedded in a palaeosol directly above associated ancient palm root molds. Moreover, the radiocarbon chronology of the sand dune layers above reveals a stratigraphically-consistent chronology for rapid sand dune development. While the notion of “missing deposits” is conceivable, they are nonetheless not there. Our excavations and deep probing at 'Anakena revealed the earliest signs of human presence, with no evidence in the clay deposit be-

low. We maintain that, until unequivocal indications emerge for earlier cultural strata, claims of "missing deposits" are just special case pleadings for negative evidence.

### *Veracity of 'Anakena Deposits as Evidence for Colonization*

In addition to questioning our chronology for 'Anakena, Flenley and Bahn (2007a, 2007b) challenge whether we can state that the dates obtained there reflect initial or early colonization. They ask, if 'Anakena was the site of the first settlement, why are there settlements at two other locations at the same date? Of course, there is significant ambiguity as to what the "same date" means in historical perspective. The "same date" in the measurement terms of radiocarbon dating is roughly within a century, or about five human generations. There would be plenty of time for even a small number of people – certainly those comprising five generations – to travel 10 or 20 kilometers to other parts of the island. There are no natural barriers to stop people from venturing across the island regardless of where they first settled. We would even expect to find structures built "at the same date" regardless of the years or decades between their construction events. Given the island's size, colonization and human expansion over the island should appear contemporaneously as a consequence of the precision of archaeological dating.

### *Assumption of Slow Population Growth Rates*

Flenley and Bahn (2007a, 2007b) make a tacit assumption that Rapa Nui experienced uncharacteristically slow population growth, despite the speed with which the rest of eastern Polynesia was settled. If one were to assume a slow population growth rate (e.g., ca. 1%) we might imagine a scenario in which centuries of Polynesian presence on Rapa Nui would remain all but invisible. Like the assertion of "missing deposits," such a scenario is based on the *lack of evidence* (see Anderson 1995 on the notion of "cryptic settlement" in East Polynesia). The few documented cases of an isolated group of humans colonizing empty environments point to population growth rates of around 3.4% (Birdsell 1957). Based on a comparable rate, we would expect that even a small number of people (50) would expand to well over a thousand in just over a century (Figure 2).

Specifically, population could grow to 2000 in just 123 years starting with 50, or in 100 years from 100, in 76 years from 200, and in 63 years from 300. Even the smaller starting populations can grow to significant numbers in a short time. In light of documented human population growth rates, it seems some researchers in the Pacific are held in the embrace of a contradiction: rapid population growth enabled colonization of hundreds of far-flung islands almost simultaneously, but then suddenly growth reverted to a remarkably, indeed inexplicably, slow rate that follows once these colonists settled their newly discovered islands. Such a contradictory argument violates the basic tenets of demography and evolutionary biology, and significantly, the actual documented cases (Birdsell 1957).

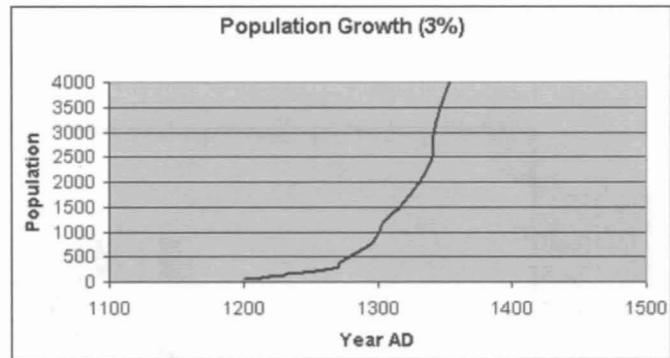


Figure 2. Plot of human population growth on Rapa Nui based on an initial logistic rate of 3.0% (see Birdsell 1957 where he documents three cases of logistic growth in human populations as high as 3.4%). If we assume a small founding population of about 50 arriving on Rapa Nui in AD 1200 with an initially large growth rate enabled by an unpopulated landscape, this rate, in one hundred years, would produce a population of approximately 1200. Numbers consistent with earliest observers (e.g., 3-4000) could have easily been reached before AD 1400, even considering that the growth rate would have slowed as populations filled the island.

### *Independent Evidence of First Colonization*

Flenley and Bahn (2007a) imply in their argument that Polynesian colonists first set foot elsewhere on the island, thus the later (ca. AD 1200) chronology now established at 'Anakena represents a significantly later expansion to this prime part of the island. We find such an idea dubious given the island's small size and the probability of rapid human population growth. But there is another set of evidence that points to the event of colonization at about AD 1200. While Flenley and Bahn might suppose Polynesian colonists waited centuries after their arrival to leave traces of their presence at 'Anakena, it is difficult to maintain the idea that introduced Pacific rats *also* waited centuries before their expansion to 'Anakena (e.g., see Fenchel 1974; Wilmschurst and Higham 2004 on rat expansion and human colonization in the considerably larger islands of New Zealand). The evidence is unambiguous: at 'Anakena, rat bones are completely absent and then first appear in great abundance in the same basal layer with charcoal, obsidian, other artifacts, and other faunal remains of fish, bird, and sea mammal (Hunt 2007; see also Steadman et al. 1994, Skjølsvold 1994b). No cultural remains pre-date, in the stratigraphic or chronological records, the presence of the introduced rat.

### *Rejection of Standard Means for Evaluating Radiocarbon Dates*

Finally, we find it disheartening that Flenley and Bahn (2007b:11, emphasis added) regard the careful evaluation of the bridging arguments between radiocarbon dates (Figures 3 and 4) and archaeological conclusions as merely "*fashionable*." Seeking reliable and valid answers employing an empirical standard – the basis of science – is not merely fashion. We analyzed radiocarbon dates to under-

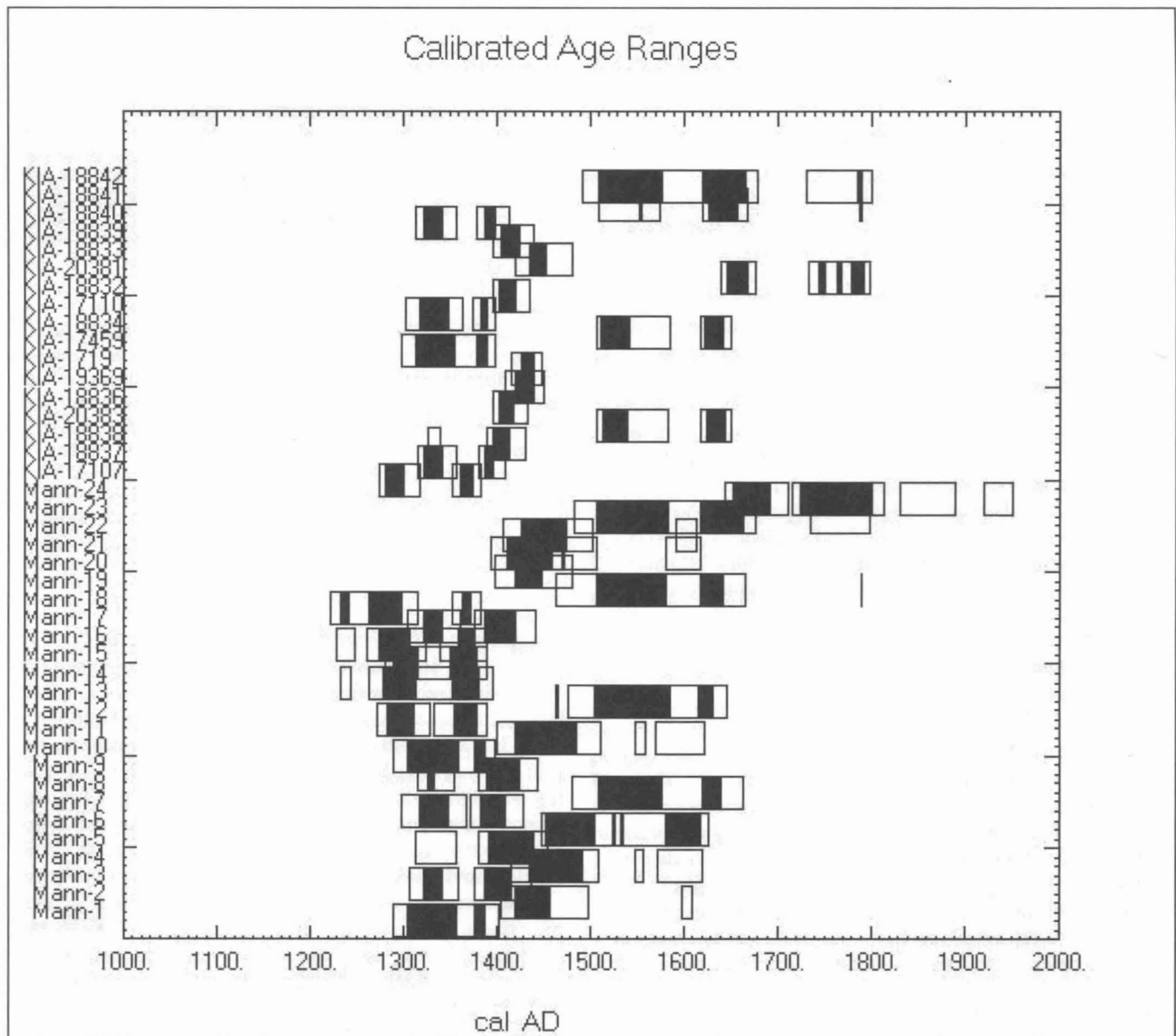


Figure 3. Calibrated radiocarbon dates (n=42) for charcoal associated with deforestation and erosion of primeval soils from locations throughout Rapa Nui (data from Mann et al. 2003:135; Mieth and Bork 2004, 2005; Mieth et al. 2002).

stand what we know reliably about the archaeological record on Rapa Nui. To accomplish this we used a widely accepted protocol known as “chronometric hygiene.” As pointed out some time ago (e.g., Dean 1978; Dunnell and Readhead 1988), radiocarbon dates cannot always be unambiguously related to an event of archaeological interest. In this way the “chronometric hygiene” approach provides simple guidelines for accepting dates as reliable and valid measures of the prehistoric events we investigate.

For example, the protocols standardize efforts to avoid the common problem of high-inbuilt age or other spurious results from samples of wood/charcoal from long-lived trees, samples of mixed materials (e.g., charcoal and soil), samples for which corrections for isotopic fractionation, reservoir effects, etc., have not been made, or samples not

replicated by one or more samples from the same or directly adjacent stratigraphic contexts. Replicating dates, while not foolproof, reduces the probability of accepting results that may be from samples of high-inbuilt age, particularly where the wood taxon has not been identified. As the extensive use of “chronometric hygiene” in New Zealand (e.g., Anderson 1991; Higham and Hogg 1997) and elsewhere in the Pacific (e.g., Spriggs and Anderson 1993; Liston 2005) has demonstrated, there are many ways in which radiocarbon dates (i.e., the radiocarbon *event*) can be significantly older than the archaeological *event* (e.g., colonization, occupation, etc.).

In our work, the radiocarbon dates excluded in estimating the chronology for Rapa Nui’s colonization were

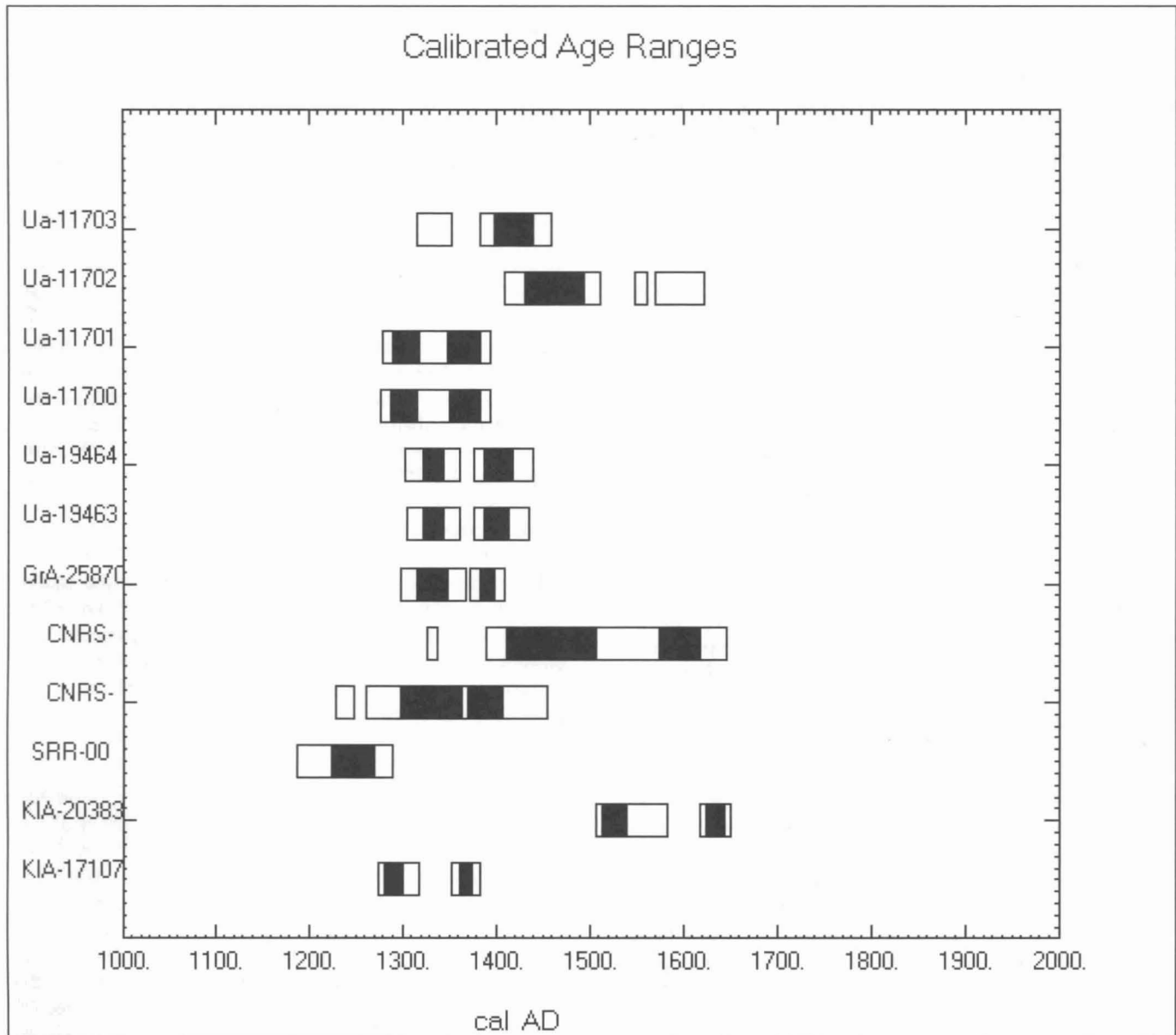


Figure 4. Calibrated radiocarbon dates (n=12) from Rapa Nui for ancient palm endocarps with cultural associations by context (archaeological, burned, and/or rat-gnawed). Data compiled from Dransfield et al. (1984); Martinsson-Wallin and Crockford (2002); Mieth and Bork (2003, 2004); and Orliac (2003).

- 1) single, non-replicated dates whose reliability cannot be demonstrated (e.g., potentially from old wood, etc.);
- 2) dates from unacceptable materials (e.g., coral) and samples with mixed isotopic fractions (e.g., "bulk" samples of "charcoal and soil mixed"); or
- 3) uncorrected dates (i.e., when corrections are not possible; e.g., from marine organisms, etc., lacking necessary laboratory analysis), that are known to be too old by varying, but unknown, amounts.

For example, Orliac and Orliac (2005:31) recently reported a single date obtained from palm wood charcoal of ca. AD 700. However, dating palm wood is certainly prob-

lematic given its high-inbuilt age (Taylor and Higham 1998). This potential must be considered in evaluating the radiocarbon record. We invite Flenley and Bahn to explain which of these criteria are dispensable in evaluating the reliability and validity of radiocarbon dates, particularly in estimating archaeological events such as colonization of an island.

Regarding our analysis of radiocarbon dates (Hunt and Lipo 2006), Flenley and Bahn (2007b:11) write, "the assembling of nine dates from different locations and different contexts seems fraught with problems – why should one reasonably expect them to be dating the same thing?" We analyze and report eleven pre-750 BP dates, nine from



'Anakena, and two reported from "agricultural sites" (Hunt and Lipo 2006; see Martinsson-Wallin and Crockford 2002 who compiled a large number of dates). To answer their question: we analyze this set to evaluate an archaeological event; the chronology of Rapa Nui colonization. Thus the different contexts – indeed the more the better – document the same thing: *human presence* on the island. Because we ask, "When was Rapa Nui settled?" dates from across the island comprise the statistical population. This is identical to the many studies that have established chronology in New Zealand (e.g., Anderson 1991; Higham and Hogg 1997; Wilmshurst and Higham 2004) and elsewhere in the Pacific (e.g., Spriggs and Anderson 1993; Liston 2005).

### *False Assertion of A Priori Criteria for Acceptable Dates*

Contrary to what Flenley and Bahn (2007b:11) believe, we do not exclude early dates because they form a tail in the distribution. There is no criterion stipulating exclusion on such grounds. The "tail" of the radiocarbon distribution (i.e., pre-750 BP dates) is precisely what we analyze. The notion that a long, cryptic human presence will result in an invisible archaeological and radiocarbon record (cf. Anderson 1995) might be true in cases with slow population growth rates on the entirely different scale of continents, but it is difficult to argue that such a pattern would fit diminutive Rapa Nui. Moreover, the notion of an "invisible" archaeological record ignores the fact that introduced *Rattus exulans* would be a large, immediate, and archaeologically-visible presence, as shown in the 'Anakena faunal evidence (Hunt 2007). Any notion of rats waiting in the wings to reproduce in large numbers defies all logic; their populations inevitably erupt and expand where there is an abundant food supply. Alternatively, one might argue that human colonists arrived, but the introduction of rats occurred later. Such conjecture would suggest that archaeological deposits existed below those containing rat bones. This is not the case for Rapa Nui; evidence of initial human presence and abundant rats exist in stratigraphic association (Steadman et al. 1994; Skjølsvold 1994b; Hunt 2007; see also Barnes et al. 2006).

### *Problems with Dating Lake Core Sediments*

Flenley and Bahn (2007b:11) complain that we reject all lake-core dates. Yet our intent was to analyze the dates from *archaeological* contexts to estimate the time of Rapa Nui's colonization. Certainly *reliable* dates from lake-cores or swampy deposits could be relevant to building chronologies, particularly where analysts quantify charcoal particles in concert with vegetation changes or presence of introduced plants (e.g., Athens et al. 2002; Burney et al. 2001; Burney and Burney 2003). However, there are many problems in the Rapa Nui lake-core dates, perhaps including the integrity and resolution afforded by the sedimentary records. We discuss the chronological problems below.

### *Ecological Change and the Presence of Humans*

Finally, Flenley and Bahn (2007b:12) question whether ecological changes (i.e., initial deforestation) will closely mark the time of Polynesian arrival. They suggest people might engage in "pre-agricultural activities such as living on sea birds, fish, sea mammals, etc." Yet in contradiction, Flenley and Bahn (2007b:12) argue that lake-core records, through detection of ecological changes, are more likely to reveal the earliest signs of human activity than archaeology. The contradiction assumes that "pre-agricultural activities" would *not* be registered in the archaeological record. The faunal record at 'Anakena shows otherwise (e.g., Steadman et al. 1994; Hunt 2007). Flenley and Bahn's notions also imply that introduced Polynesian cultigens were abandoned while people pursued "pre-agricultural" subsistence; and second, introduced rats would remain invisible for hundreds of years. Neither is biologically plausible. Colonists undoubtedly engaged in agricultural activities, as well as hunting, gathering, use of fire, and acquisition of resources such as obsidian and basalt. It would be naïve to envision something akin to a post-colonization Neolithic Revolution occurring on the island, especially since crops must have arrived with colonists. This is another example of attempting to base conclusions on the absence of evidence. Finally, Flenley and Bahn should clarify their contradictory statements about pollen evidence, ecological change, and visibility in the archaeological record.

### *Uncritical and Circular Use of Linguistic Models*

Flenley and Bahn (2007b:11) state that arrival of humans on Rapa Nui around AD 1200 "ignores the evidence of glottochronologists who place the island's colonization in the early centuries AD." This point of critique is more than 40 years out of date. Emory (1946: 1963) pioneered work on historical linguistics in Polynesia. In his 1963 paper Emory used glottochronology (and uniquely shared words) with a still small and poorly-understood radiocarbon record from the region to estimate settlement dates in Polynesia. In his presumed migrations from the Marquesas to Rapa Nui, Emory (1963:92-93) estimated dates of 1025 BC, 428 BC, and AD 500. Given Heyerdahl's (1961b:494) date "AD 386" from the Poike Ditch, Emory settled on an estimate of AD 500. Needless to say, glottochronology's validity to estimate language chronologies was rejected long ago by mainstream linguists when rates of lexical change were shown to vary dramatically (Bergsland and Vogt 1962). In any case, by the 1960s researchers in Polynesia replaced glottochronology with linguistic sub-grouping models of shared innovations (e.g., Green 1966). These models compare contemporary languages, assuming innovations in isolation, and their validity in chronological reconstructions (relative and absolute) is highly suspect. As Bloomfield (1933:318) cautioned long ago, the presuppositions of linguistic sub-grouping models are never fully realized, so that "the comparative method cannot claim to picture the historical process." Research in Polynesia (e.g., Biggs 1972;

and see Terrell et al. 1997) has shown specific language relationships to be far more complex than implied in the simplistic A to B to C migration models of the 1960s. The common tactic of validating colonization dates (e.g., Emory settling on AD 500 for Rapa Nui) based on linguistic models has languished as a misleading circular argument in Polynesia (Hunt et al. in press).

### *When and Why did Deforestation Occur?*

Flenley and Bahn (2007a, 2007b) cling to dates from the lake-core samples, particularly those from Rano Kau, by simply asserting that they reliably date the arrival of Polynesian colonists on Rapa Nui. Yet, as has long been known and widely recognized, the radiocarbon results from these sediment cores are plagued with problems.

Yet, Flenley and Bahn (2007a, 2007b:12) claim that deforestation was complete by AD 1000. This stunning – and isolated – declaration puts the completion of deforestation at least 600 years earlier than indications from an impressive corpus of radiocarbon and stratigraphic evidence from across the island (Arnold et al. 1990; Orliac 2000; Mann et al. 2003; Mieth and Bork 2003, 2004; Mieth et al. 2002; Hunt 2007; see below). This claim also contradicts what Flenley has reported in early and recent publications for the same cores (e.g., Flenley 1993:43; Flenley and King 1984; Butler and Flenley 2001:81). To fit their claims for deforestation, Flenley and Bahn (2007a, 2007b) “cherry pick” dates from an array of inverted and widely disparate radiocarbon results from cores 1 and 2 at Rano Kao. Drawing on results from Core 1 from Rano Kao, Flenley and Bahn (2007b; see Flenley et al. 1991) appear to settle on two dates at ca. 1000 BP associated with a pollen record for the loss of forest (but see Flenley and King [1984:49] where they initially rejected the validity of the 1040±60 BP date, SRR-2039, given contamination from in-washed soil carbon).

In a significant 2004 publication, Butler et al. (2004) show that dates on various kinds of samples from Rano Kau are unreliable, and likely hundreds (even thousands) of years too old. For example, three dates from samples taken from the same upper-most core depths of Rano Kau 2 vary more than 600 years (Butler et al. 2004:400). In adjacent core depths from Rano Kau 2 bulk sediment, plant fragments, and pollen samples returned ages ranging from more than 5700 years in age (at only 1.29–1.31 m depth) to those below in the same core dating to between ca. 900 BP (11.35–11.45 m), ca. 2200 BP (13.40–13.42 m), and ca. 1600 BP (14.85–14.95 m) (Butler et al. 2004:400). Regarding the chronology for Rano Kau in particular, Butler et al. (2004:395) conclude:

This series of <sup>14</sup>C ages seems to indicate that both old and young organic components in the sediment are deposited contiguously and that the depositional history of these cores is more complex than previously known. Previous age determinations on bulk sediments from Easter Island,

which also show anomalous dates, may be too simplistic.

Given these results and the clear warning, it is difficult to see how Flenley and Bahn (2007a, 2007b) justify selecting two dates from a larger pool of demonstrably problematic dates from bulk sediment samples to make their definitive statements about deforestation and colonization chronology. Precisely dating human presence on the island based on the onset of regular fires and vegetation change from pollen requires a dense and continuous sedimentary record with fine-grained analyses and multiple reliable (i.e., at least stratigraphically-consistent) radiocarbon dates on demonstrably short-lived specimens (e.g., dating macro-botanical specimens using AMS dating and thus avoiding high-inbuilt ages, additions of old organic sediments, etc., but as Butler et al. 2004 show, even these attempts may prove problematic given the resolution afforded by the Rano Kao sedimentary record itself). The ideal conditions and analyses for lake-core reconstructions of vegetation change *do not* yet exist for Rapa Nui. As Mann et al. (2003:139, emphasis added) correctly pointed out:

A close look at Flenley's data show that sediments dating to the time of Polynesian settlement are either missing or highly disturbed in the cores he analyzed from the crater lakes. In his core from Rano Raraku, sediment samples that were <sup>14</sup>C-dated to 480 and 6850 years BP are only 15 cm apart in the stratigraphy.... In Rano Kau, ages of 1000 yr BP were obtained on sediments 5 m apart in the core. *There are no continuous records of ecological change over the last 2000 years on Easter Island.*

Significantly, Flenley and Bahn's (2007a, 2007b:12) declaration of virtually complete deforestation by AD 1000 is also at dramatic odds with the chronology established by three independent research teams working on every part of the island, and publishing more than 54 radiocarbon dates, including dates (12) directly on palm endocarps (Figures 3 and 4). These teams document a chronology for deforestation that consistently begins after AD 1250–1300, with signs of forest plants persisting into historic times (see Figures 3 and 4; Hunt 2007; Mann et al. 2003; Meith and Bork 2004; Orliac 2003). Orliac (2003:192–193), and others (e.g. Kamminga and Cotterell 1984), have outlined problems in Flenley's lake-core chronology for deforestation and the attempts to correlate it with cultural decline. Flenley and Bahn's (2007b) argument for deforestation by AD 1000 makes no sense with regard to their own notions that resource depletion led to cultural collapse, but such “collapse” would have occurred some 600–700 years after complete deforestation! Such an argument is at serious odds with ideas that resource depletion led to the abandonment of statue production and transport as well. The abundant evidence from multiple field studies does not support Flenley

and Bahn's claim for an early date of deforestation across the island, nor does it fit their story of an ecologically-induced collapse (see Peiser 2005; Rainbird 2002).

### *The Extinct Palms' Lifespan*

The question of the extinct palms' lifespan is relevant. However, we do not have an answer. Flenley and Bahn (2007a; 2007b) assert that the *Jubaea chilensis* palms of Chile live 2,000 years, but the basis of their speculation is unfounded. Chilean palm expert Juan Grau (2004) refers to the possibility of a few palms greater than 700 years old on the mainland. While long-lived (i.e., hundreds of years), in recent published research on the palms Tomlinson (2006:10) writes, "the age of the palm can only be determined accurately from knowledge of its seed planting date." Extrapolated ages for palms range from 100 to 740 years (Tomlinson 2006:10). Along these lines, it is noteworthy that the *Jubaea chilensis* palm planted from seed in the Temperate House at Kew Garden (England) in 1843, just 164 years ago, is now a large mature palm whose growth is damaging the glass of the greenhouse building. The Rapa Nui evidence may suggest a potential lifespan of about 400 years or slightly more, considering the duration of forest survival following human colonization (until about AD 1650; see Orliac 2000), but this remains only hypothetical.

However, using analogies between a living palm and an extinct one may be moot. Botanists have classified the palms that once covered Rapa Nui as *Jubaea* sp. or *Paschalococos disperta*, designating them a unique species or even distinct genus from the native palms on the Chilean mainland. While the data for maximum life span do not exist, attempts to estimate the extinct palm's lifespan across different species or genera would remain problematic nonetheless. Moreover, the equable climate of Rapa Nui differs significantly from the continental environment of Chile, further confounding estimates by analogy for palm growth rates or lifespan.

Flenley and Bahn (2007a, 2007b) spuriously argue that given a 2,000-year lifespan for the palms, if rats were mostly responsible for deforestation, the palms should still be on Rapa Nui. However, nowhere does Hunt (2006, 2007b) argue that rats were the sole agent of deforestation. Instead, Hunt raises the question of their *relative* impact, just as Flenley and his colleagues did in their original publications concerning the island's deforestation. For example Flenley et al. (1991:104, emphasis added) wrote:

the effects of introduced rodents on the biota of oceanic islands are known frequently to have been disastrous, .... and it seems that Easter Island may have been no exception. Whether the extinction of the palm owes more to the prevention of regeneration by rodents, or to the eating of the fruits by man, or to the felling of the mature trees, *remains an open question*.

We wonder what resolved the "open question" as the historical and ecological evidence for significant impacts of rats on native vegetation has only greatly expanded (e.g., Athens et al. 2002; Towns et al. 2006).

If the extinct palms of Rapa Nui did have a lifespan greater than about 400-500 years, the cumulative impacts of fire may have finished off the deforestation that rats began by depressing the regeneration of new trees. And Flenley and Bahn (2007b:12) should know that rats destroy palm seedlings (Figure 5) in numerous documented cases (e.g., Campbell and Atkinson 1999). In any case, the relative impacts of rats, fire, or other effects have not been adequately evaluated in the work of Flenley and his associates. Instead, they have precluded testable hypotheses by reducing the issue to a simplistic, unanswerable question such as: "What were they thinking when they cut down the last palm tree?" (Diamond 1995:68; see also Bahn and Flenley 1992:214). Clearly the synergy of impacts from rats as an



Figure 5. Prehistoric rat-gnawed palm endocarps from Rapa Nui (from the collections in the P. Sebastian Englert Museum); rat-gnawed endocarps such as these provide ideal radiocarbon dates for the chronology of the extinct palms on Rapa Nui.

invasive species, direct human actions, and perhaps even climatic variations, make the history of deforestation one best examined in terms of its complexity and ecosystem interactions.

### *Rats and Other Pacific Islands*

Flenley and Bahn (2007b:12) point out that many islands have forest that persisted despite rat introductions. Two points deserve reiteration here: A long list of islands *not* deforested says little, if anything, about Rapa Nui. Rapa Nui is not Fiji, Rarotonga, Tahiti, nor New Zealand. To argue a simplistic "rats = deforestation" made on such generalizations assumes that the diverse islands of the Pacific have the same history, biogeography, and ecology. This is clearly not the case. Even as Diamond (1985:602) pointed out many years ago for island biota, "rats have caused catastrophic extinction waves on some islands, a few ex-



inctions on others, and no visible effect on still others." Second, no one to our knowledge argues that rats (alone) succeeded in total deforestation of any island, although research now suggests that perhaps they actually could. Rats appear to have devastated the lowland *Pritchardia*-dominated forests of the Hawaiian Islands, prior to any direct human impacts of fire or felling (Athens et al. 2002). Thus the question of the *relative* impact of rats remains an open question. Otherwise, it is incumbent upon Flenley and Bahn to demonstrate how rats had *no impact* on the forest of Rapa Nui, and by implication, that humans were the sole agent of deforestation.

### *'Anakena Evidence*

Flenley and Bahn (2007b:12) write,

"interestingly, the excavation at 'Anakena by Steadman et al. (1994) found that the abundance of rat bones had two peaks at different levels in the stratigraphy, about 200 years apart (ca. 1000 BP and ca. 800 BP). Perhaps these could represent the enormous plagues hypothesized by Hunt, although they scarcely seem high enough to do so. But throughout the 200 years, and even after it, there were abundant fish and dolphin bones, suggesting that people were still able to go to sea in sizeable canoes. So the rats had apparently not succeeded in deforesting the island in 200 years or more."

While their points made here are perhaps trivial, they seem to reflect Flenley and Bahn's misreading or misunderstanding of our work. It is worth refuting each to illustrate our point:

The age they cite from Steadman as "ca. 1000 BP" comes from uncorrected marine samples (likely to be at least 350 years younger in calibrated age [ca. 650 BP/AD 1300] given the marine reservoir effect). They ignore other dates from Steadman's sequence, but select one at "800 BP" (note: three dates in this range overlap statistically). Furthermore, there is no rationale for treating "1000 BP" as a discrete point in time against which to compare "800 BP" and then posit a 200-year interval between the layers that are the sources of these dated samples. These ages are problematic, and may be statistically the same. Their point reflects a naïve reading of the archaeological and radiocarbon evidence.

Nowhere does Hunt (2006, 2007) hypothesize *enormous plagues* of rats. This is an attempt to sensationalize and "controversialize" the issues at hand. Ecological fieldwork has documented rat densities of 45-75 rats per acre on Kure Atoll (Wirtz 1972). At this real-world density, Rapa Nui could have had about 1.9-3.1 million rats within a very short period of time (see Fenchel 1974). Given contemporary ecological theory relating population size and growth rates in environments with abundant food supplies and no natural predators, Flenley and Bahn should explain why

such a density for Rapa Nui would be unreasonable, as well as tell us how many rat bones one should expect to find in excavations as evidence for fewer rats.

Flenley and Bahn ignore the larger faunal record from 'Anakena (see Hunt 2007: Fig.12), and they fail to appreciate how depositional factors can result in variable samples sizes of faunal components. The fish bones from 'Anakena and other excavations represent primarily inshore taxa (Martinsson-Wallin and Crockford 2002). Moreover, the presence of sea mammal bones does not require sizable canoes and deep-sea fishing, as often cited. In ethnographic cases, dolphins, for example, are taken by using stones struck together in the water to disorient the animals echolocation system and drive them into shallow waters, either from small canoes or by people in the water, and then taking them by hand with little or no specialized technology (e.g., S. Aswani, personal communication 2007; Bloch et al. 1990; Porcasi and Fujita 2000; Takegawa 1996). Sea mammal bones from 'Anakena (the only location where they are reported in any quantity for the island) probably represent this specialized capture method, as reported for this location in historic times. Deep-sea fishing may have never been a common strategy on Rapa Nui, with or without suitable trees for canoes.

A critical review of the often-repeated claims like those made by Flenley and Bahn for Rapa Nui reveal that many lack evidence, or that some researchers are too eager to settle on simplistic conclusions.

### *Violence, Warfare, Cannibalism, and Population*

Flenley and Bahn (2007a:5) present claims about the nature of violence and warfare in Rapa Nui prehistory and argue "obsidian spearheads proliferated after the deforestation, and there is skeletal material that shows severe wounds" as evidence of "internal warfare" (Flenley and Bahn 2007b:13). While there was undoubtedly competition among ancient islanders, there is remarkably little evidence of "warfare." The primary evidence for it comes from the oral histories collected late in the post-European contact history and subsequent to the devastating demographic collapse induced by introduced disease and slaving. Archaeological evidence for pervasive warfare remains ambiguous. The island's archaeological record boasts no obvious defensive structures such as the hilltop forts like those found on Rapa (Kennett et al. 2006) and elsewhere. Use of concealed caves as places of refuge may reflect inter-group violence, but they suggest conflicts on a relatively small-scale. The caves of refuge might also represent places of hiding constructed and used as a defense against slave-trading raids that began in the early 19<sup>th</sup> Century.

Analysis of use-wear in published studies shows that the so-called "obsidian spearheads" (*mata'a*) were tools (Figure 6) used primarily for activities such as cutting and scraping plant and animal materials (Church and Rigney 1994; Church and Ellis 1996). As Church and Rigney (1994:104) conclude, the predominant use of *mata'a* was for plant processing (i.e., cutting and scraping green plant



Figure 6. Stemmed obsidian artifacts (*mata'a*) from the P. Sebastián Englert Museum, Rapa Nui; these specimens were photographed for documentation and not selected to represent particular forms. The variability in form is typical and shows that objects potentially suitable for "weapons" comprise only a very small fraction of these tools. Shape and use-wear studies indicate that these were multi-purpose tools that share stems for hafting.

parts). They conclude, "these activities are inconsistent with the original proposed function of these tools as spear-points" (Church and Rigney 1994:104). Prehistoric artifacts of identical form are known from Hawai'i, Tahiti, and elsewhere in East Polynesia, where they are routinely identified as cutting and scraping tools used mainly on plant materials.

Our inspection of hundreds of these tools from museum collections and those from our own field work shows that few, if any, possess traits that would make them effective weapons (Figure 6). While it is conceivable that on rare occasions an obsidian tool (*mata'a*) might have been used to inflict injury, just as today a kitchen knife might serve as a weapon, there is no evidence for their regular use in inflicting lethal injury. That a European visitor regarded hafted obsidian tools as weapons may reveal more about their anxiety, than about the function of the tools. Early European visitors were mistaken about other things as well.

Skeletal material from Rapa Nui provides little in the way of support for widespread warfare or violence. Published studies of hundreds of skeletons show that evidence for violent injury or fatalities is *minimal*. Based on a study of 2,618 human bones, Owsley et al. (1994:164) report that only 2.5% of crania show antemortem fractures with evidence of healing or perimortem breakage caused by traumatic injuries. Owsley et al. (1994:174) conclude,

"most skeletal injuries appear to have been nonlethal. Few fatalities were directly attribut-

able to violence. The physical evidence suggests that the frequency of warfare and lethal events was exaggerated in folklore."

Talk of cannibalism makes the story even more sensational. Yet, even as Bahn (1997) has pointed out, cannibalism remains unproven for Rapa Nui. Bahn suggests there is "no smoke without fire," and that the prevalent ethno-historic discourse on the topic suggests that it had occurred. If cannibalism occurred with some frequency on the island, we would expect to find evidence in the archaeological record, as documented in places such as the American Southwest (e.g., White 1992), and in Fiji (Cochrane et al. 2004). Despite numerous excavations and recovery of a large number of human bones, to date, no unambiguous evidence for cannibalism has emerged. We await evidence more substantial than tales drawn from the oral traditions collected centuries after European contact (see Routledge 1919:212-213). While the evidence cited for pervasive warfare is weak, it is likely that competition for critical resources was a major factor in the evolution of Rapa Nui society.

Competition is widely expressed in ancient Pacific Island societies, including places where deforestation did not occur. The deterministic equation of deforestation with social and demographic crises cannot account for the many counter-examples, such as New Zealand or Hawai'i. Research in anthropology and biology reveals that competition is expressed in diverse processes and outcomes.

Curiously, Flenley and Bahn (2007b:13) write that we "also pose the question of how the island's population could have risen to crisis proportions if people only arrived in AD 1200." Nowhere do we raise such a question. Despite the repeated speculations, we see little, if any, evidence that the island's population ever reached the large numbers some have cited (e.g., a population of 10-20,000). The archaeological record indicates that settlement pattern was dispersed and subsistence activities extensive.

As we show above, mathematically, populations could have grown to large sizes even with a AD 1200 colonization time frame (Figure 2; see Birdsell 1957). However, there is no evidence that the Rapanui population reached the huge numbers cited. Speculations about a large population do not support a longer chronology, regardless of the predilections of some to make circular arguments.

## CONCLUSION

The dramatic story of Rapa Nui's so-called "ecocide" was constructed with faith in a long chronology, speculations of a huge prehistoric population size, and a spuriously dated

lake core record of deforestation for the island. Our ongoing field research, the recent impressive palaeo-environmental work of several teams, as well as comparative research recently published for the Hawaiian Islands, has changed some perspectives and raises new questions about Rapa Nui's historical ecology. In Hunt's (2006, 2007) recent reviews he has examined archaeological, palaeo-environmental, and contemporary ecological evidence in consideration of a significant role for the Pacific rat in Rapa Nui's ecological catastrophe. The fact that rats alone can devastate forests raises the issue of their relative impacts for Rapa Nui, as well as for other island ecosystems. The role of rats has often been underestimated, yet this does not deny that direct human actions such as the use of fire likely played decisive roles in deforestation. Additional research should disentangle the relative impacts of contributing factors. In short, the environmental catastrophe of Rapa Nui likely has a complex history, one that has been obfuscated by simple speculations on the intentions of the person cutting down the last tree. As the story of rats as invasive species suggests, perhaps the "last tree" simply died, and rats ate the last seeds (Hunt 2007:499). We argue that Rapa Nui may tell of the effects of invasive species, invasional meltdown (Simberloff and Von Holle 1999), and the synergy of these introduced elements when they reach evolutionary isolates in the remote islands of the Pacific.

Flenley and Bahn (e.g., 2002, 2007b) have convinced themselves that Rapa Nui society crashed before Europeans arrived in 1722. Apparently in support of Rapa Nui as a scary parable for our own environmental woes, they believe deforestation caused population collapse. Diamond (1995, 2005) has profited from telling the same story. Yet, this assumption conflates the undisputed fact of deforestation with the speculation that the population was much larger, but then collapsed before European contact. Stated simply, no evidence exists for a pre-European contact population collapse. It is merely supposition, repeated over and over. A pre-contact demographic collapse remains untested, undemonstrated archaeologically. The historic slave-trading, epidemic diseases, intensive sheep ranching, and tragic population collapse – indeed the genocide of the Rapanui People – is well documented, and has been recognized for a long time (e.g., Métraux 1957). It seems that Flenley and Bahn (2007a, 2007b) are unaware of both the historic impacts on Rapa Nui as well as the significant literature on the biological impacts Europeans wrought in the Americas and the Pacific. As Peiser (2005) has pointed out, some writers have transposed an actual documented historic genocide with prehistoric "ecocide" where the victims are blamed for their own demise.

Flenley and Bahn (2007b) suggest that questioning the impacts of European contact reflects "anti-European bias," or a "Euro-phobic" model. We find such attributions revealing and troubling. Following such logic, are Flenley and Bahn therefore, anti-Polynesian or Euro-centric? Unfortunately, such notions inevitably obscure the generation of scientific knowledge and reduce historical questions to little

more than political rhetoric. What happened in the past occurred regardless of the political framing imposed by some today. We believe the issues should be resolved with historical evidence and the empirical standards of modern archaeology. Let the political implications follow from our research, rather than allow politics to dictate our findings.

It does not matter whether Rapa Nui offers a parable for today's urgent environmental problems. They are urgent problems nonetheless. Nowhere do we even hint that the current global environmental crisis should be ignored. Our concern echoes Grayson and Meltzer (2003:590), that science and critical environmental issues are both done a disservice by relying on accounts with virtually no empirical support. As Hunt (2006:419) remarked, "mistakes or exaggerations only lead to oversimplified answers and hurt the cause of environmentalism. We will end up wondering why our simple answers were not enough to make a difference in confronting today's problems."

Finally, it is worth reiterating that science is not based on belief, faith, or assertion, but on the hard evidence we acquire in attempts to prove ourselves wrong. We invite Flenley and Bahn to join us in evaluating the complexity of Rapa Nui's archaeological, ecological and evolutionary history. In the framework of science, we challenge them to open their minds to the emerging picture of Rapa Nui's remarkable prehistory, even if it is sometimes different than all of us have supposed.

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